TWO NEW LICHENS: CLADONIA SQUAMOSULA VAR. SUBSQUAMOSULA AND C. SULCATA VAR. STRIATA WITH NOTES ON CHEMOTAXONOMY WITHIN THE SPECIES

by

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ABSTRACT

Archer, Alan W. Two new lichens: *Cladonia squamosula* var. *subsquamosula* and *C. sulcata* var. *striata* with notes on chemotaxonomy within the species. *Muelleria* 6(5): 383-388 (1987). — Two new lichen varieties, *Cladonia squamosula* var. *subsquamosula* which occurs in Australia and *Cladonia sulcata* var. *striata* which occurs in Australia and New Zealand, are described and the chemotaxonomy of all Australian varieties within the two species is discussed. Additional distribution data is reported for *C. sulcata* var. *sulcata* and *C. sulcata* var. *wilsonii*.

INTRODUCTION

The exact level at which chemical variations in the lichen-forming fungi should be given taxonomic recognition has been the subject of much discussion (Hawksworth, 1974; Hawksworth, 1976; Brodo, 1978; Elix *et al.*, 1984). It has been suggested that some taxonomic recognition should be given to morphologically similar materials which differ chemically (Brodo, 1978) although there is at present no general agreement among lichenologists as to the level at which such recognition should be given. This paper describes new chemical variations in two species in the lichen genus *Cladonia, C. squamosula* Müll. Arg. and *C. sulcata* A. W. Archer. The taxa possessing these variations are here described as new varieties, following the guidelines proposed by Hawksworth (Hawksworth, 1976) for the naming of chemical variations *(vide infra)*.

METHOD

The lichen compounds present in the specimens examined were identified by thin-layer chromatography of acetone extracts, using the mobile phases described by Culberson (Culberson, 1972; Culberson *et al.*, 1981) and the separated compounds were detected with sulphuric acid (Culberson, 1972) and MBTH (Archer, 1978). The presence of bourgeanic acid was confirmed by mass spectrometry (cf. Bodo *et al.*, 1973). Fertile specimens of *Cladonia squamosula* contain barbatic acid and this compound is not well separated from homosekikaic acid using the standard conditions for thin-layer chromatography (Culberson, 1972). An improved separation of these two compounds was obtained on silica by using a mobile phase composed of: ethyl acetate 75/ ethanol 20/ ammonia 5. In this system the following Rf values were obtained: thamnolic acid, 0; barbatic acid, 0.3; homosekikaic acid, 0.6. The presence of homosekikaic acid was also confirmed by high performance liquid chromotography (J. A. Elix *in litt.*, 1985).

TAXONOMY

Cladonia squamosula. Müll. Arg. Flora, Jena 66: 19 (1883) var. **squamosula.** TYPE: Australia, Queensland, Toowoomba; Hartmann, 1882. (HOLOTYPE: G!; ISOTYPE: MEL 6551!).

Cladonia subsquamosa var. *pulverulenta* Vainio, Acta Soc. Fauna Flora fennica 4: 449 (1887). — *Lichen pulverulentus* R. Brown ex Bennett, Iter. austr. 531 (1876),

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nom. nud. in sched.; R. Brown ex Vainio, Acta Soc. Fauna Flora fennica 4: 449 (1887), *nom. nud. pro syn.* — *Cladonia pulverulenta* Crombie, J. Linn. Soc. Bot. 17: 392 (1880), *nom. nud. pro syn.* TYPE: Australia [Tasmania], "Mons Tabulans" [Mt Wellington], 1802-05, *R. Brown* ex Bennett, Iter. austr. 531 (HOLOTYPE: BM!)

Cladonia elegantula Müll. Arg. Flora, Jena 70: 56 (1887). — *Cladonia squamosula* f. *elegantula* (Müll. Arg.) des Abb., Revue Bryol. Lichénol. 34:824 (1966). TYPE: Australia, New South Wales, Illawarra, 1881, *Kirton.* (LECTOTYPE (see Des Abbayes, 1966): G!. ISOLECTOTYPES: MEL 6547!, NSW L4392!). Victoria, Ovens River, 1882, *McCann.* (SYNTYPES: G!, MEL 6541!).

ALSO EXAMINED:

Western Australia — Stirling Range, Toolbrunup Peak, 19.iv.1980, *? coll.* (PERTH 000906).

South Australia — Ashbourne, 40 km SSE. of Adelaide, 2.vi.1964, *D. J. Whibley 1397* (AD 97519493); Lower Mt Lofty Range, 55 km SSW. of Adelaide, - .vi.1968, *V. Cruickshank* (AD 97410442); Mt Compass, 50 km S. of Adelaide, 7.vii.1968, *V. Cruickshank* (AD 97410446); Honans Scrub, 25.vii.1980, *N. Donner 7034* (AD 4877); near Glenelg River, South Australia/Victoria border, 26.vii.1980, *N. Donner 7058* (AD 4867).

Queensland — Allumbah, "North Queensland", 29.iii.1910. *B. Waller* (NSW, L1918); Amity Point, Stradbroke Island, 16.v.1973, *R. Rogers 2178* (BRIU); Near Mt Coolum, 100 km N. of Brisbane, 1981, *N. Stevens* (BRIU); Kirrima Rd, 32 km WNW. of Cardwell, 20.vi.1984, *H. Streimann 28714* (CBG); Wallam Falls Rd, 27 km W. of Ingham, 21.vi.1984, *H. Streimann 28816* (CBG).

New South Wales — Parramatta, 1.x.1900, *E. Cheel* (NSW); Exeter, -.x.1907, *Miss Betts* (NSW); Mt Boss State Forest, 51 km NW. of Wauchope, 20.x.1978, *H. Streimann 7142* (CBG); Guerilla Bay, 2.ix.1981, *H. Streimann 15710* (CBG).

Australian Capital Territory — Condor Creek, 25 km W. of Canberra, 1.ix.1981, *A. Archer 1114* (BM, NSW); Mt Franklin Road, near Mt Aggie, 14.xi.1981, *A. Archer 1206C* (NSW); Kowen Forest, 18 km W. of Canberra, *H. Streimann* (CBG); Little Collins Creek, Brindabella Range, 34 km SW. of Canberra, *H. Streimann* (CBG); Booroomba Rocks, 30 km SSW. of Canberra, *H. Streimann* (CBG).

Victoria — Mt Macedon, - .iv.1886, F.R. M. Wilson (NSW); Oakleigh, 7.x.1887, *F. R. M. Wilson* (NSW L3803); Trentham, -.xi.1887, *F. M. Campbell* (NSW); Tyers Lake, -.vi.1889, *F. R. M. Wilson* (NSW); Whitehorse Creek, Blue Range, 24.ix.1964, *R. Filson 6509* (MEL 40188).

Tasmania — Notley Gorge, 26.xi.1983, *A. Archer 1720* (NSW); Beaties Tarn, 9 km N. of Maydena, 6.xii.1983, *A. Archer 1638A* (NSW); Gordon Road, near Mt Wedge, 16.xii.1983, *G. Kantvilas 132/83.*

Lord Howe Island — Mt Gower, -.viii.1911, *W. W. Watts* (NSW L1920).

DISCUSSION:

Des Abbayes (1966) examined J. Müller's specimens of *C. squamosula* and *C. elegantula* from Geneva and selected Kirton's specimen from New South Wales as the lectotype of *C. elegantula.* He concluded that *C. elegantula* was only a form of *C. squamosula* possessing small isidioid squamules, in contrast to the larger squamules characteristic of typical *C. squamosula.* Both of these forms are found, together with intermediate forms which possess large conspicuous squamules near the base of the podetia with a decrease in size towards smaller isidioid squamules near the apices of the podetia. Thus the separation of form *elegantula* can no longer be justified and it is here reduced to synonymy with *C. squamosula* var. *squamosula.* An examination of the holotype of *C. squamosula* and all type material of *C. elegantula* showed that none contained homosekikaic acid.

C. squamosula var. *squamosula* is widely distributed throughout Australia where it grows on dead wood. It also occurs in New Zealand and has recently been reported from Chile (Ahti and Kashiwadani, 1984).

Cladonia squamosula Müll. Arg. var. **subsquamosula** A. W. Archer, var. nov.

Cladonia intermedia Krempelh. ex F. Wilson, Pap. Proc. Roy. Soc. Tasmania 1892: 151 (1893), *nom. nud.*

Cladonia intermedia "(Del. ex Nyl.) Wils." sensu Wetmore, Rev. Bryol. Lichénol. 32: 247 (1963), non *Cladonia fimbriata* var. *coniocraea* f. *intermedia* Delise ex Nyl. Prodr. Lich. Novae Caled.:3 (1859).

Sicut *Cladonia squamosula* var. *squamosula* sed acidum homosekikaicum continens. Thallus K+ flavescens, Pd+ flavescens; acida thamnolicum et homosekikaicum continens.

Primary squamules persistent, 1-3 mm long, 0.5-1 mm wide, subpalmately lobed, margins crenate to incised, green above, white below. *Podetia* growing from the upper surface of the primary squamules, 10-20(-25) mm tall, 0.5-1.5 mm diam., cylindrical or tapering towards the apices, simple or rarely branching, escyphose, sterile podetia acute; podetia ecorticate and squamulose, squamules c. 0.3 mm long near the base of the podetia, becoming smaller and isidioid, 0.1 mm long, near the apices; podetial wall 0.15-0.2 mm thick, *Apothecia* brown to dark brown, clustered, 0.5-1.5 mm diam., terminal on podetia, the tips of fertile podetia often open to the interior. *Ascospores* eight per ascus, colourless, simple, ellipsoid, 12-15 μm long, 3-4 μm wide. *Thallus* K+ yellow, KC−, Pd+, yellow; containing thamnolic and homosekikaic acid, with barbatic acid in the apothecia.

TYPE COLLECTION:

Australia, New South Wales, Wentworth Falls, 90 km W. of Sydney, 150° 22′ E, 33° 45′ S, alt. c. 900 m, 1.vi.1985, *Archer 1751* (HOLOTYPE: MEL 1048970. ISOTYPE: NSW).

ALSO EXAMINED:

Western Australia — Porongorup Range National Park, 40 km N. of Albany, 15.x.1980. *N. Sammy* (PERTH 810024 & 810111); 1bidem 17.x.1980, *N. Sammy* (PERTH 810085).

South Australia (selected specimens only, 5/18) — Hahndorf, 25 km SE, of Adelaide, 27.viii.1971, *N. Donner 3685* (AD 97410365); West end of Kangaroo Island, 12.ix.1971, *G. Jackson 823* (AD 9206); Comaun Forest, 30 km SE. of Naracoorte, 3.v.1973, *R. Seppelt 2537* (AD 97645142); Mt Lofty Ranges, 7 km E. of Springton, alt. 300 m, 17.xii.1976, *J. A. Elix* (ANUC); Barossa Range, Menglers Hill, 4 km E. of Tanunda, 27.x.1981, *J. A. Elix* (ANUC).

New South Wales (selected specimens only, 5/12) — 50 km E. of Glen Innes along Highway 38, alt. 1000 m, 18.viii.1976, *J. A. Elix* (ANUC); 85 km E. of Armidale, alt. c. 1400 m, 14.x.1977, *Archer 415* (NSW); Below Tianjara Falls, 33 km NNE. of Ulladulla, alt. 380 m, 21.v.1979, *J. A. Elix* (ANUC); Guerilla Bay, 150° 13′ E, 35° 40′ S, alt. c. 50 m, 28.v.1983, *Archer 1731* (NSW); Berowra Creek, Galston Gorge, 30 km NW. of Sydney, alt. 50 m, 16.ii.1985, *Archer 1725* (CBG, G).

Victoria — 12 km E. of Marlo, alt. 10 m, 20.xi.1978, *J. A. Elix,* (ANUC).

Tasmania — Cladonia intermedia sensu Krempelhuber, sine loc., *Dr. Story,* (M, MEL 6651); Snug Falls Track, *G. Bratt & M. Bratt 3474* (HO 40449); Russell Falls Track, *G. Bratt & J. Cashin 73/508* (HO 40492).

Norfolk Island — Mt Pitt, on stump of *Cyathea brownii,* 27.xii.1981, *R. Goldsack* (NSW).

DISCUSSION:

Cladonia squamosula var. *subsquamosula* is distinguished from var *squamosula* in containing homosekikaic acid.

The new variety has a restricted distribution when compared with that of var. *squamosula.* It occurs on dead wood in south-western Western Australia, south-eastern South Australia, Victoria, eastern New South Wales and Tasmania. The material from Tasmania collected by Dr G. F. Story (a military surgeon in Tasmania (Kantvilas, 1983)) was sent to A. von Krempelhuber in Munich who gave the specimen the manuscript name "Cladonia intermedia" but the name was never validly published as neither Wilson (1893) nor Wetmore (1963) gave a description or diagnosis of the taxon. Both of the specimens of Story's Tasmanian collection housed at Munich and Melbourne contain thamnolic and homosekikaic acids and are included in *C. squamosula* var. *subsquamosula.* The occurrence of homosekikaic acid, an orcinol meta depside, with thamnolic acid, a β-orcinol meta depside, is unusual. Homosekikaic acid is not biogenetically related to thamnolic acid and therefore var. *subsquamosula* falls into category 3C of Hawksworth's proposed guidelines for the taxonomic treatment of chemical variations in lichens (Hawksworth, 1976, Table 1, p. 157) i.e. the presence of a biogenetically distinct compound allied to distributional differences. Hawksworth (1976) suggested the rank of variety for taxa showing this type of chemical variation and this proposal has been followed here. Homosekikaic acid is reported to occur with β-orcinol depsidones in the sub-generic group *Helopodium* and in the sub-groups *Cladonia* and *Furcatae* (Huovinen & Ahti 1982) and is here reported to occur in the group *Squamosae,* to which group *C. squamosula sens. lat.* belongs. The structure of homosekikaic acid has

some features in common with didymic acid, which occurs with thamnolic acid in the sub-generic group *Cocciferae*. It is possible that both didymic and homosekikaic acids are formed from the same pair of polyketides, one with a pentyl group and one with a propyl group. Two synthetic routes are suggested, one involving esterification and o-methylation to form homosekikaic acid and the other, to give didymic acid, involving decarboxylation and formation of a C-C bond with loss of water to form a furan ring. A quantitative examination of a specimen of *C. squamosula* var. *subsquamosula* (*Archer 943,* H) by high performance liquid chromatography, (Huovinen *et al.,* 1985) showed the specimen to contain 0.2% thamnolic acid and 0.46% homosekikaic acid (K. Huovinen *in litt.,* 1985). Traces of sekikaic acid were also present.

Cladonia sulcata A. W. Archer, Muelleria 5:115 (1982) var. **sulcata.**

Cladonia sulcata was originally reported to occur only in Victoria and Tasmania (Archer, 1982) but the range of var. *sulcata* now extends from South Australia to New Zealand.

Additional Specimens Examined:

Australia, South Australia — Mt Lofty Ranges, 3.xi.1968, *R. Rogers 1515* (AD97649657).

Australian Capital Territory — Smokers Gap, Corin Dam Rd, alt. 1200 m, 2.v.1982, *A. W. Archer 1318A* (ANUC, H).

New Zealand: North Island — North Auckland, Mangonui County, Karikari Peninsula, *J. K. Bartlett 28919* (WELT). *South Island* — Nelson, Dun Mt, *J. K. Bartlett 19805* (WELT).

Cladonia sulcata var. **wilsonii** (A. W. Archer) A. W. Archer & J. K. Bartlett, New Zealand J. Bot. (in press).

Cladonia wilsonii A. W. Archer, Muelleria 5: 274 (1984).

Cladonia wilsonii was originally reported to occur only in Australia (Archer, 1984) but the known range now extends south and east to Macquarie Island (Filson and Archer, 1986) and New Zealand (Archer and Bartlett, *loc. cit.*).

Cladonia sulcata var. **striata** A. W. Archer, var. nov.

Cladonia diffissa auct.

Sicut *Cladonia sulcata* var. *sulcata* sed acidum norsticticum continens. Thallus K+ flavescens; KC−; Pd+ flavescens; atranorinum et acida norsticticum et bourgeanicum continens.

Primary squamules persistent or evanescent, 1-2 mm wide, 2-4 mm long, green above, white below, esorediate. *Podetia* arising from the squamules, 10-20(-30) mm tall, greyish white, simple at the base and then becoming branched, each branch longitudinally grooved and becoming split, axils open; cortex continuous at the base, then becoming verruculose and areolate; esorediate; podetial wall 100-250 μm thick. *Apothecia* always present on the tips of the podetia, dark brown to reddish-brown, convex, 0.4-0.8 mm diam., *ascospores* eight per ascus, colourless, simple, ellipsoid, 12-14 μm long, 3-4 μm wide. *Thallus* K+ weak yellow; KC−; Pd+ yellow; containing atranorin, norstictic and bourgeanic acids.

Type Collection:

Australia, New South Wales, near First Rocks, Mona Vale Road, 18 km NNW. of Sydney, 151° 10′E, 33° 42′S, alt. c. 150 m, 14.iv.1984, *Archer 1667.* (Holotype: MEL 1047761. Isotype: CBG, H, NSW).

Also Examined:

Western Australia — Point Mount Henry, Manning, 27.vi.1970, *N. Sammy* (PERTH NS840894); near Princes Royal Harbour, 18.vi.1980, ? coll. (PERTH 000828).

South Australia — Yorke Peninsula, 7 km W. of Ardrossan, 30.viii.1977, *J. A. Elix 3728* (ANUC); 19 km E. of Stenhouse Bay, alt. 16 m, 31.viii.1977, *J. A. Elix 3755* (ANUC).

Queensland — Nerang River, Numinbah Valley, alt. 120 m, 20.viii.1976, *J. A. Elix 2548* (ANUC).
New South Wales (selected specimens only, 5/39) — Sutherland, ix.1906, *Townsend* (NSW); Gladesville, 30.vii.1911, *M. Flockton* (NSW); Batehaven, 0.5 km W. of Surf Beach, 14.ix.1975, *J. A. Elix 1241* (MEL 1017175); near Mt Dowe, alt. 1550 m, 12.x.1981, *Archer 1160* (NSW); Twofold Bay, no date, *White* (MEL 6526).
Australian Capital Territory — Honeysuckle Creek, 30 km SSW. of Canberra, alt. 1100 m, 2.iv.1983, *Archer 1479A* (MEL 1047764).
Victoria — Kew, 29.iii.1886, *F. Wilson* (NSW); Narbethong, -.vii.1906, *Mrs Goodyear* (NSW); Nug Nug, 50 km SE. of Wangaratta, 18.xi.1979, *Archer 791* (CBG, MEL 1047763); 8 km E. of Tawonga, alt. c. 700 m, 22.xi.1979, *Archer 860* (MEL 1047762).
New Zealand: North Island — Auckland, Waitakere Coast, alt. 25 m, 27.x.1983, *J. K. Bartlett 27057, 27058* (WELT); Mt Te Aroha, alt. c. 1000 m, 27.iii.1982, *J. K. Bartlett 28271* (WELT).

DISCUSSION:

The three varieties of *Cladonia sulcata* referred to above differ in chemistry and distribution. Var. *wilsonii* and var. *striata* are examples of chemosyndromic variation (Elix 1982; Elix *et al* 1984; Hawksworth and Hill 1984); the minor compound norstictic acid in var. *wilsonii* becomes a major compound in var. *striata* and the minor compound stictic acid in var. *striata* becomes a major compound in var. *wilsonii*. This type of chemical variation has been given taxonomic recognition at the species level (Elix 1981), e.g. *Parmelia amphixantha* Müll. Arg. with usnic and stictic acids and *P. pseudoamphixantha* Elix with usnic and norstictic acids, but Hawksworth (1976) proposed that, where one substance was replaced by a biogenetically closely related substance and this replacement was correlated with geographical differences, the chemical variations be given recognition as varieties, i.e. category 2B, *vide supra*. This proposal has been followed here. Both varieties occur in mainland Australia but var. *wilsonii* has a more southerly distribution whereas var. *striata* has a more northerly distribution and does not occur in Tasmania or the South Island of New Zealand. *C. sulcata* lacks the corymbose form of the somewhat similar *C. corymbescens* Nyl. ex Leighton and is further distinguished from that species by the absence of fumarprotocetraric acid.

C. sulcata var. *striata* contains atranorin and norstictic and bourgeanic acids, together with traces of stictic, cryptostictic and constictic acids. The presence of bourgeanic acid and the small apothecia differentiate *C. sulcata* from the Northern Hemisphere *C. cariosa* (Ach.) Sprengel. The preferred habitat of *C. sulcata* is on soil in semi-exposed positions; it has not been found growing on wood.

C. sulcata var. *striata* has been referred to previously as *Cladonia diffissa* (Wilson 1889; Cheel 1914; Archer 1982, 1984), based on *C. cariosa* var. *diffissa* (Wilson 1889a), but the holotype of this last taxon is *C. enantia* Nyl. (Archer 1986).

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